Nutrition and Milk Protein Production

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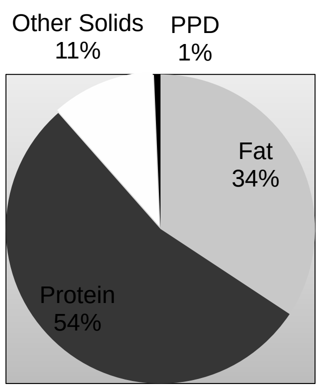
Milk Protein – Area of Opportunity?

- Conversion of feed nitrogen (N) to milk N is an area of opportunity for dairy
  - 25-30% conversion efficiency of feed N to milk N as milk protein (Bequette et al., 1998)
- Dietary protein sources are expensive
- Environmental concerns
  - Excess dietary N results in greater N excretion
  - MUN values should be 8 – 12, higher indicates N or protein waste
- Multiple component pricing
  - Historically high value for protein relative to fat
- Consumer demand for milk protein strong
  - Per capita cheese consumption > 71 kg in 2008
  - Greek Yogurt phenomenon

Milk Check Income
Cornell T & R Center – June 2012



Cornell T&R Center – June, 2012

Milk Protein – the economics….

- Again, it's pounds of milk protein produced that's economically important.
- The challenge is to produce high pounds of milk WITH high milk protein %.
- Focus on total fat and protein yield/cow/day
- How do you become a member of the 6 lb. club or the very exclusive 7 lb. club?

How to get there…

83.5 lbs. with 4.0% fat, 3.2% protein

x.835 x.835

3.34 + 2.672 = 6.012 lbs.

95.0 lbs. with 3.45% fat, 2.9% protein

x .95 x.95

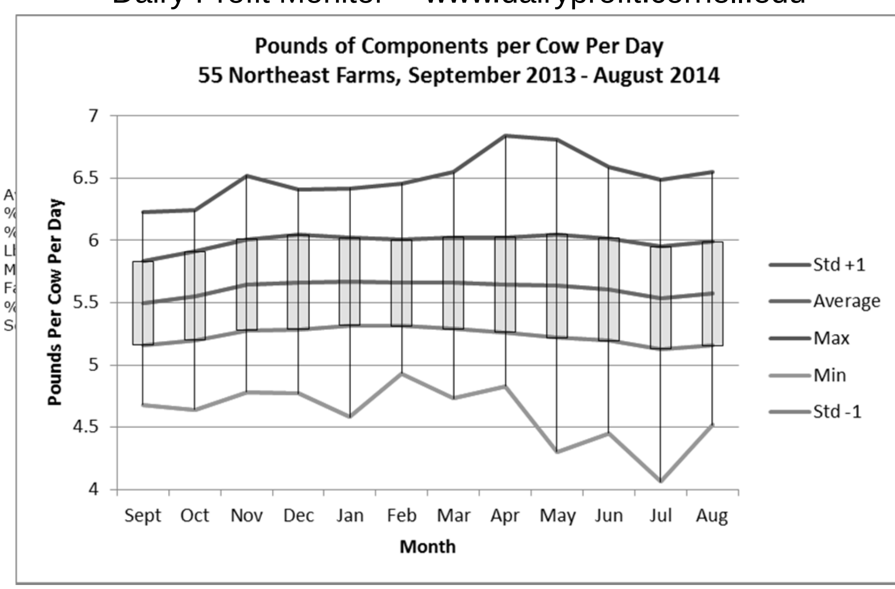
3.2775 + 2.755 = 6.0325 lbs.

98.0 lbs. with 4.0% fat, 3.2% protein

x.98 x.98

3.92 + 3.136 = 7.056 lbs.

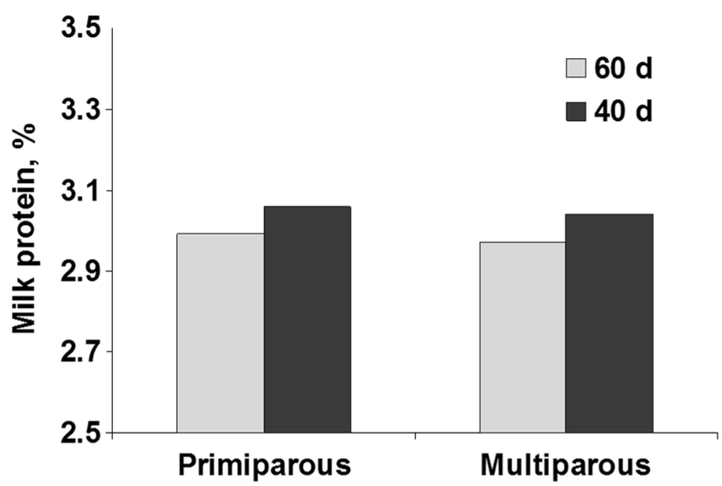
Dairy Profit Monitor -- www.dairyprofit.cornell.edu



Factors that increase milk protein yield

- Nutritional/managerial factors that increase milk yield
  - Milking frequency
  - Forage quality
  - Cow health
  - Environmental factors (facilities, comfort, heat abatement, etc.)
- Shortened dry period length?
- Ration formulation approaches that specifically increase milk protein

Shortening the dry period from 60 to 40 days increased milk true protein percentage in the subsequent lactation

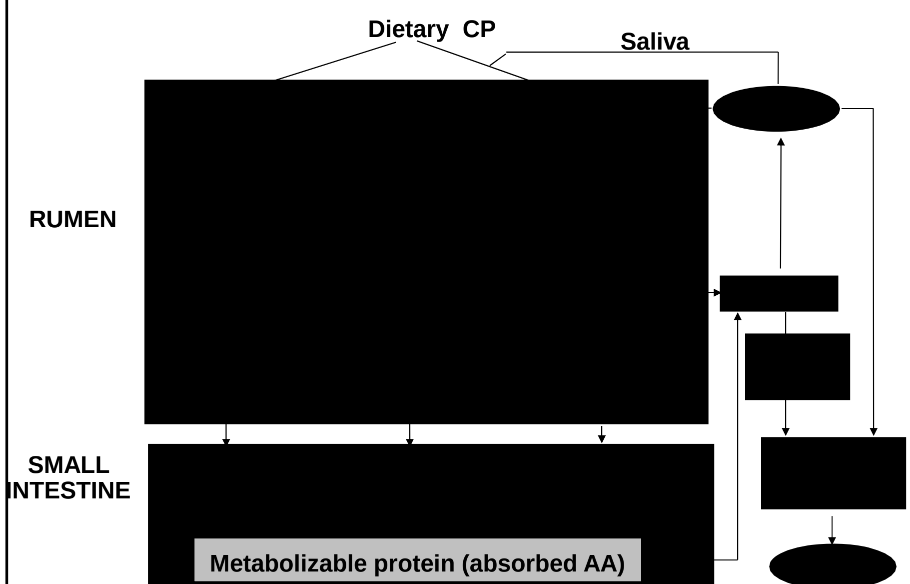


Grusenmeyer et al., 2007; SEM = 0.02; Trt, P < 0.001

Ration formulation approaches that specifically increase milk protein.

*

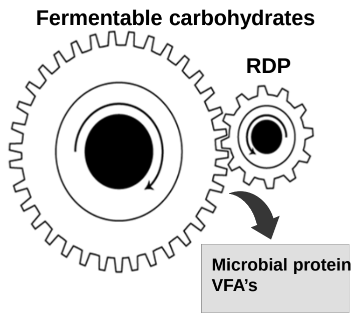
Protein metabolism in cows



Schwab, 2005

Factors affecting RDP and recycled N requirements

1) Intake and mixture of fermentable carbohydrates



2) Quality of RDP (relative supplies of protein, free AA and ammonia **and** rate of degradation)

CP and MP in Commercial Herds – Are They Related?

Herd	CP, %	MP, g
A	15.2	2864
B	16.2	2779
C	16.1	3322
D	17.6	2950
E	17.7	2646

We need to balance for Metabolizable Protein (MP) in dairy rations

*Cows don't actually have a CP requirement.

*To move forward we must be using dynamic computer models to predict MP.

*It's Metabolizable protein (absorbed AA) that she needs for productive functions.

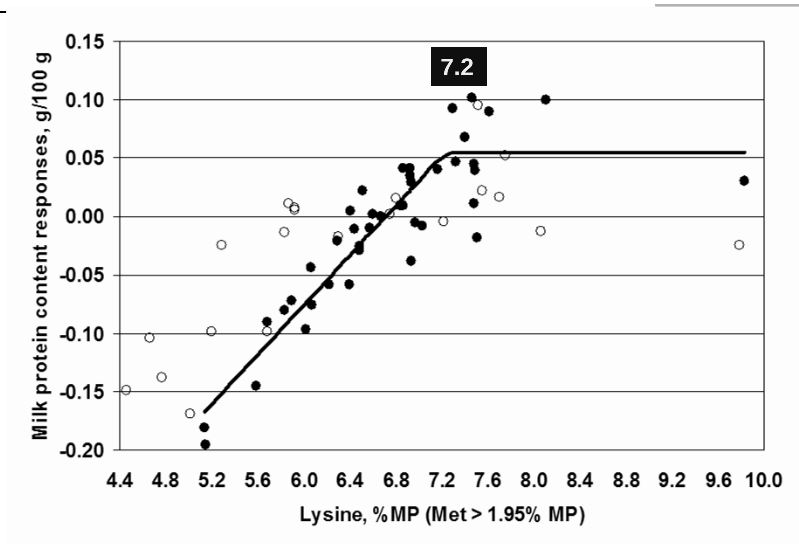
*Once we have maximized microbial protein yield (most economical source of AA), then we can look at AA balancing.

Limiting amino acids in lactating dairy cows

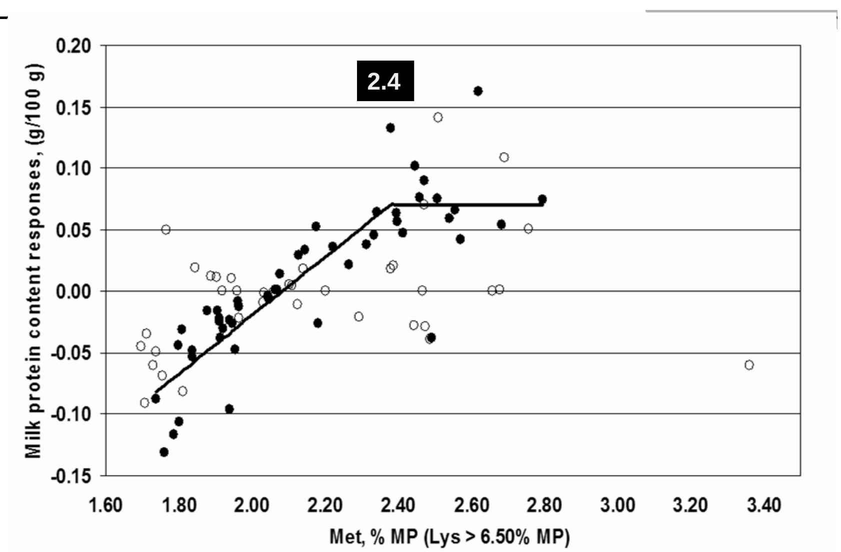
1. **Met, Lys, and His identified most often as first limiting**
2. **Met: when most RUP is provided by oilseed meals, animal-derived proteins, or a combination of the two**
3. **Lys: when corn or feeds of corn origin provide most or all dietary RUP**
4. **His: when grass silage, barley and oat diets are fed with or without feather meal as sole source of supplemental RUP**

Courtesy: Dr. Chuck Schwab

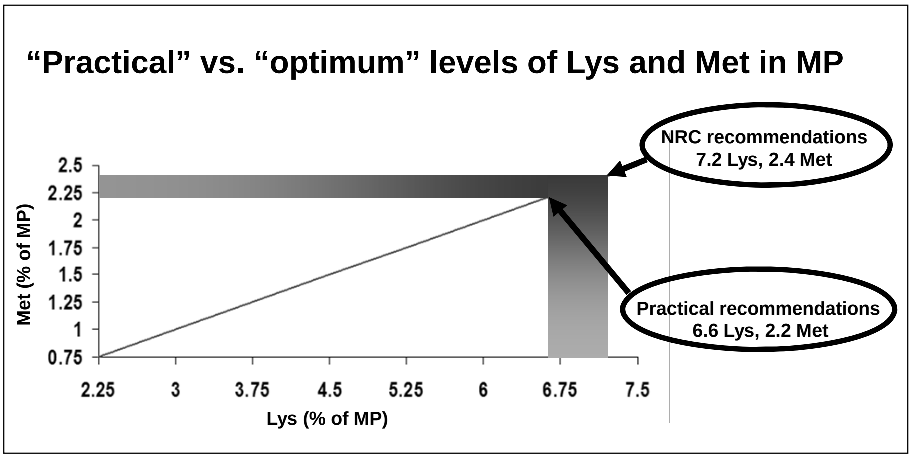
Lysine Plot (NRC, 2001)



Methionine Plot (NRC, 2001)



"Optimum" vs. "practical" levels of Lys and Met in MP



Courtesy: Dr. Chuck Schwab

Optimum AA concentrations in MP

	NRC Model		
	Lysine	Methionine	Optimal Lys/Met
2009 Results	6.80	2.29	**2.97**
2010 Results	6.89	2.32	**2.97**
	CPM Model		
2009 Results	7.46	2.57	**2.90**
2010 Results	7.23	2.68	**2.70**
	AMTS/NDS (CNCPS 6.1 biology)		
2009 Results	6.68	2.40	**2.78**
2010 Results	6.84	2.54	**2.71**

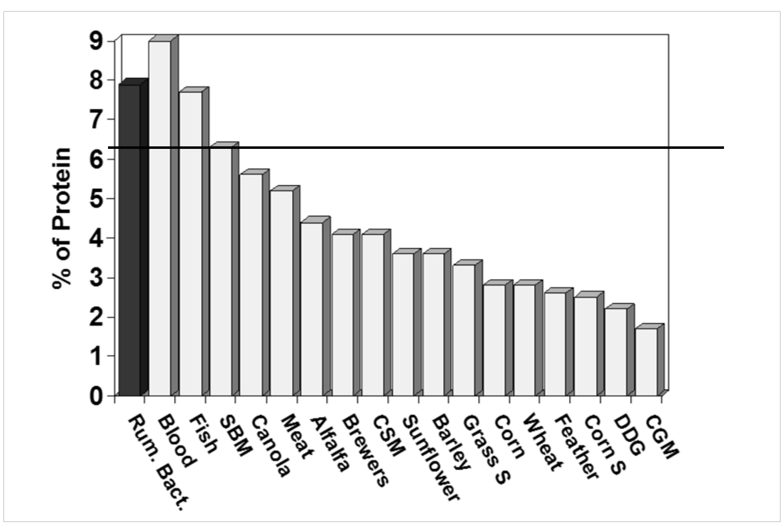
Schwab et al. (2009) and Whitehouse et al. (2009, 2010)

Optimum AA concentrations in MP in new model

	Lysine	**Methionine**	**Optimal Lys/Met**
	AMTS/NDS (CNPS 6.5 biology) milk protein yield		
2015	7.00	2.60	**2.7**
	AMTS/NDS (CNCPS 6.5 biology) milk protein %		
2015	6.77	2.85	**2.4**

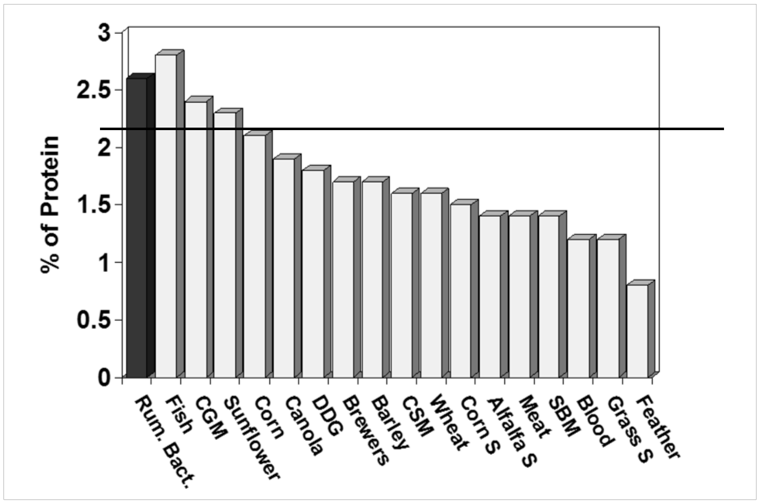
Van Amburgh (2015)

Comparison of lysine in rumen bacterial protein and feedstuffs



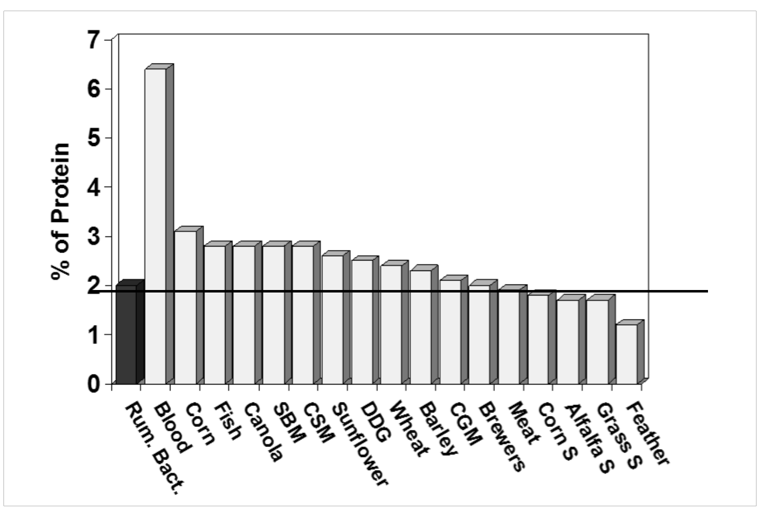
Courtesy: Dr. Chuck Schwab

Comparison of methionine in rumen bacterial protein and feedstuffs



Courtesy: Dr. Chuck Schwab

Comparison of histidine in rumen bacterial protein and feedstuffs



Courtesy: Dr. Chuck Schwab

Replacement of some highly digestible RUP (blood, poultry and feather meal) with rumen-protected Met

Item	High RUP	Low RUP	Low RUP + Met
RDP, % DM	10.4	10.0	10.0
RUP, % DM	8.0	6.9	6.9
CP, % DM	18.4	16.9	16.9
Lys, g/d	183	174	176
Met, g/d	49	46	53
Lys, % MP	6.3	6.5	6.5
Met, % MP	1.7	1.7	1.9
Lys/Met in MP	3.8/1	3.8/1	3.3/1

Noftsger and St-Pierre (2003)

Replacement of some highly digestible RUP (blood, poultry and feather meal) with rumen-protected Met

Item	High RUP	Low RUP	Low RUP + Met
Milk, lb/d	101.6	94.4	102.5
DM intake, lb/d	51.3	51.0	51.9
Milk protein, lb/d	3.04	2.82	3.17
Milk protein, %	2.98	2.99	3.09
Milk fat, lb/d	3.64	3.66	3.73
Milk fat, %	3.67	3.45	3.76
Milk N/feed N	32.0	32.7	36.2
Feed cost, $/cow	3.93	3.87	4.11
IOFC, $/cow	8.62	7.83	8.81

Noftsger and St-Pierre (2003)

Example Herd # 1 – 140 cows, tie-stall, TMR, 92 lbs. milk, 3.8 fat, 3.2 protein

- Ration parameters:
  - CP = 14.3%, RDP = 8.4% of DM
  - Rumen NH3 = 134 % of required
  - NDF = 31.4%, F-NDF, % of BW = 1%
  - Starch = 29%, sugar = 5%
  - Fat = 4.4%
  - Lys = 6.5% of MP, Met = 2.2% of MP
  - MNE = 36%
  - 59% forage

Courtesy Dr. Larry Chase

Example Herd # 1 – Ingredients, lbs. DM/day

CS	17	SBM	4
Grass HCS	12	Roast SB	1.6
Hay	3	Urea	0.1
Corn	13.3	Anim Prot	0.4
Molasses	0.46	RPAA	0.02
Sugar	0.7	Min-vit	1.6
Bypass fat	0.3		

Commercial Rumen Protected Methionine (RPM): Meta-Analysis

- Studies
  - 17 for Mepron
  - 17 for Smartamine
  - 1 Study for both
- 75 diet comparisons
  - 1040 individual cows
- Average of 20 g RP-Met/d
  - 12 g metabolizable Met

Courtesy Dr. Sarah Boucher

Patton R.A., 2010

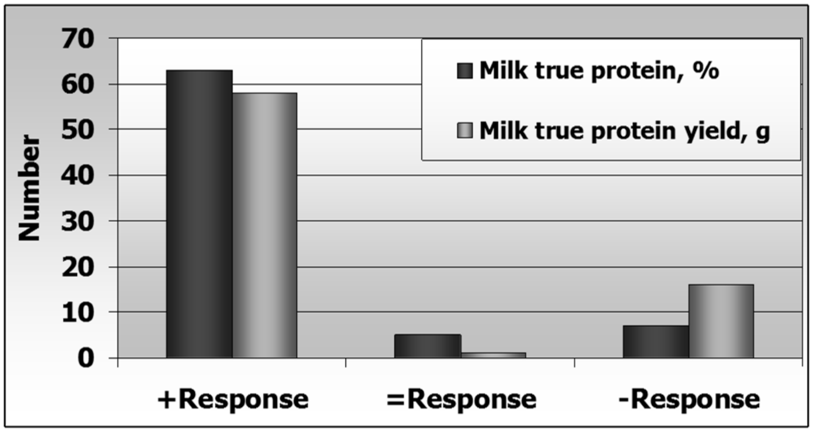
Patton, 2010: Meta-Analysis

Item	Mean	Min.	Max.
DMI, kg	-0.04	-2.10	1.50
Milk, kg	0.02	-4.20	4.40
Milk true protein, %	0.07	-0.09	0.35
Milk true protein, kg	0.03	-0.07	0.19
Milk fat, %	-0.01	-0.30	0.41
Milk fat, kg	0.01	-0.19	0.19

Courtesy Dr. Sarah Boucher

Patton, R.A., 2010

Meta-Analysis: Responses to RP-Met



Courtesy Dr. Sarah Boucher

Patton, R.A., 2010

Why variability in response to AA balancing approaches?

- Lots of reasons related to ability to predict/model responses to AA balancing
  - Other limiting AA?
  - Accuracy of both MP and individual AA predictions
  - Facility/behavioral factors that affect ruminal metabolism of rations
  - Management factors on individual dairies – feed consistency, forage dry matter & cows/pen adjustments kept current, actual DMI matching ration formulation.
  - Variation in optimal ratios at different stages of lactation
  - Signaling mechanisms related to other aspects of amino acid and/or energy supply?

Role of energy nutrition in milk protein synthesis

- Sporndly (1989) reported much stronger relationship of milk protein percentage with dietary energy intake than dietary protein intake
  - Often attributed to ruminal fermentation and microbial protein synthesis
  - Sugars, starches, and digestible fiber sources will drive microbial protein yield, not fats.

Slow-release insulin and milk protein

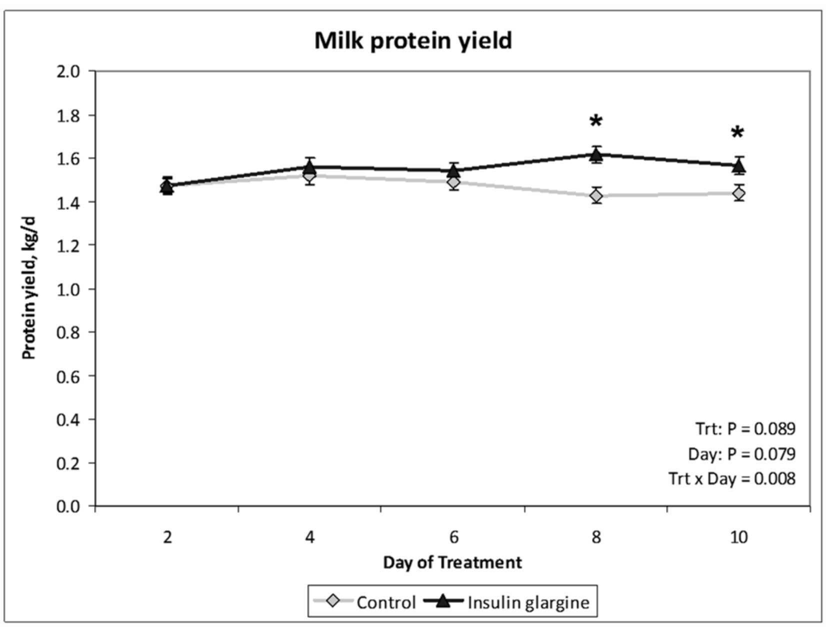
- 20 multiparous Holstein cows
  - 53 to 130 DIM, avg. 88 +/- 25
- 2 treatments given at 12 hr. intervals for 10 d
  - Control
  - 0.2 IU Insulin glargine/kg BW, 2x day
- Blood samples
  - Twice daily from coccygeal vein
  - Before morning injections, 6 hours later
- Milk samples every other day, 2x/d

Winkelman and Overton, 2011

Production Variables

Variable	Treatment			*P* -value		
	Control	Insulin glargine	SE	Trt	Day	Trt x Day
Dry Matter Intake, kg/d	26.4	26.8	0.39	0.407	<0.001	0.194
Milk yield, kg/d	48.3	47.0	0.96	0.343	0.363	0.067
Fat, %	3.17	3.46	0.091	0.035	0.463	0.142
Fat yield, kg/d	1.49	1.62	0.057	0.103	0.355	0.459
Protein, %	3.05	3.33	0.047	0.002	0.008	0.186
Protein yield, kg/d	1.47	1.55	0.031	0.089	0.079	0.008
Lactose, %	4.85	4.71	0.021	<0.001	0.334	0.463
Lactose yield, kg/d	2.35	2.21	0.048	0.053	0.307	0.013
Total solids, %	11.96	12.37	0.110	0.020	0.125	0.108
Total solids yield, kg/d	5.75	5.78	0.126	0.876	0.145	0.033
SCC (x 1,000)	70	106	37.3	0.510	0.282	0.060
MUN, mg/dl	13.4	12.4	0.3046	0.029	0.049	0.198

Winkelman and Overton, 2011



Winkelman and Overton, 2011

How about transition cow diets?

Boucher summary of AA studies in the transition cow (7 studies)

Item	# of studies reporting positive effect of AA supplementation
Prepartum DMI	2
Postpartum DMI	2
Milk yield	4
Milk fat yield	3
Milk fat, %	2
Milk protein yield	5
Milk protein, %	3

Basal diets in these studies varied WIDELY

Socha et al., 2005

Cows supplemented with Met or Met + Lys beginning precalving had increased yields of ECM, fat, and protein during early lactation

Nutrient Balances

Nutrient	Balance	%Req
ME	12.9 Mcal	153
MP	359 g	133
Rum. NH3-N	72 g	167
Rum. Pep-N	119 g	207
peNDF	0.1 kg	103
MP Lys	47.8 g	196.3
MP Met	12.1 g	174.1
Ca	3.34 g	117%
P	15.37 g	183%

Total ME Avail.	37.26 Mcal/day
Total MP Avail.	1455 g/day
MP Bact	56.3 %MP
ME Bal	12.9 Mcal
MP Bal	358.5 g
Urea Cost	0.58 Mcal
Rumen pH	6.43

Diet Concentrations

DM	51.4 %DM
Forage	55.1 %DM
CP	15.36 %DM
RDP	9.96 %DM
NDF	29.92 %DM
Forage NDF	86.80 %NDF
Forage NDF	0.62 %FBW
EE	4.4 %DM
LCFA	3.5 %DM
Lys	6.70 %MP
Met	1.95 %MP
Lys:Met	3.44
TDN	68.3 %DM
ME	2.47 Mcal/kg
NEm	1.58 Mcal/kg
NEg	0.98 Mcal/kg
Sugar (A4)	3.3 %DM
Starch (B1)	31.4 %DM

Ration Fed

Ingredient	$/hd	%DM	DM kg/day	AF kg/day
Corn Silage Processed 45 NDF NPN Medium-CNCPS-03033	0.00	33.0	4.70	14.24
Mix Silage 13 CP 56 NDF 14 LNDF-CNCPS-04068	0.00	40.0	2.52	6.30
Alfalfa Hay 17 CP 46 NDF 20 LNDF-CNCPS-04042	0.00	90.0	1.09	1.21
Corn Grain Ground Coarse-CNCPS-01038	0.00	88.0	4.83	5.49
Soybean Meal 47.5 Solvent-CNCPS-02027	0.00	90.0	1.04	1.16
Soybean Whole Raw-CNCPS-02033	0.00	90.0	0.42	0.47
Soy Plus-CNCPS-08030	0.00	89.1	0.00	0.00
Blood Meal-CNCPS-07001	0.00	90.0	0.10	0.11
Fat Hydrol Tallow-CNCPS-06012	0.00	99.0	0.10	0.10
MinVit-CNCPS-05053	0.00	95.0	0.29	0.31
Totals	0.00	51.4	15.09	29.38

Dr. Patrick French regression analysis

- 18 published transition cow studies (2002 to present)
- Prepartum MP intake, mMet intake, and mLys intake positively associated with postpartum milk protein yield (when all three in model r^2 = 0.56)
- Suggest optimum at ~ 1,300 g/d MP, 30 g/d mMet, and 90 g/d mLys

Controlled energy dry cow diet composition (as formulated)

Ration Fed			
			DM
Ingredient	$/hd	%DM	lbs/day
Corn Silage Processed 35 DM 41 NDF Medium-CNCPS-03021	0.00	32.3	12.00
Wheat Straw 5 CP 79 NDF 16 LNDF-CNCPS-03086	0.00	88.6	6.20
Citrus Pulp Dry-CNCPS-01031	0.00	88.6	2.00
Soybean Hulls Ground-CNCPS-01103	0.00	91.0	2.00
Soybean Meal 47.5 Solvent-CNCPS-02027	0.00	90.0	1.50
Canola Meal Solvent-CNCPS-02006	0.00	90.2	1.30
Blood Meal-CNCPS-07001	0.00	90.0	0.30
MinVit-CNCPS-05053	0.00	95.0	1.50
Amino Plus-CNCPS-08022	0.00	88.0	0.50
Corn Grain Ground Fine-CNCPS-01039	0.00	88.0	1.20
Totals	0.00	51.3	28.50

Nutrient Balances		
Nutrient	Balance	%Req
ME	4.0 Mcal	115
MP	115 g	110
Rum. NH3-N	21 g	119
Rum. Pep-N	65 g	168
peNDF	2.6 lbs	140
MP Lys	36.6 g	171.9
MP Met	9.0 g	154.0
Ca	6.49 g	132%
P	6.83 g	141%

Total ME Avail.	28.36 Mcal/day
Total MP Avail.	1191 g/day
MP Bact	63.8 %MP
ME Bal	4.0 Mcal
MP Bal	115.1 g
Urea Cost	0.13 Mcal
Rumen pH	6.46

Diet Concentrations	
DM	51.3 %DM
Forage	63.9 %DM
CP	12.20 %DM
RDP	7.94 %DM
NDF	42.19 %DM
Forage NDF	79.02 %NDF
Forage NDF	0.64 %FBW
EE	2.5 %DM
LCFA	1.8 %DM
Lys	7.35 %MP
Met	2.15 %MP
Lys:Met	3.41
TDN	60.7 %DM
ME	0.99 Mcal/lb
NEm	0.60 Mcal/lb
NEg	0.34 Mcal/lb
Sugar (A4)	3.8 %DM
Starch (B1)	17.0 %DM

Summary……….

- Modest increases in milk protein can occur with supplementation of individual limiting AA
- Recent reports suggest differential supplementation of Met at different stages of lactation for maximum milk protein
- Energy intake (mediated through insulin) has a strong relationship with milk protein yield
- Better responses to additional MP or AA supplementation may occur in glucogenic diets
- Mechanism may relate to specific effects of nutrients (including those not thought to be classically limiting) on regulation of protein synthesis

Summary con’t ………….

- All amino acids except for leucine and lysine can make a net contribution to glucose synthesis.
- Utilization of amino acids for gluconeogenesis is also generally supply dependent.
- Amino acids mobilized from skeletal muscle likely make a substantial contribution to glucose synthesis post calving. *

  Don’t understand regulation of mobilization
- Likely that AA are an important substrate for gluconeogenesis and adaption to lactation in the cow.

Summary con't ……….

- Dramatic dynamics of protein and AA metabolism in the transition cow
  - Mobilization from muscle and other labile body proteins
  - Use of some AA for gluconeogenesis and other specialized needs
- MP requirements of the cow during pre- and postpartum periods exceed those estimated by NRC (2001)
- Must use MP-based systems for ration formulation for cows pre- and post-partum
  - Accurate reflection of supply
  - Excess N is problematic for cow to deal with
- Despite relatively limited work and WIDE variation in basal diets, reasonable consistency of positive responses to specific AA supplementation (Met and Lys) during early lactation

Questions?

- Well-known academic – 1998 ADSA Discover Conference on transition cows
  - "The industry will not balance for MP until it is printed on a forage analysis"

Does your nutritionist balance your dairy rations for MP (Metabolizable Protein) ????